Marc SCHÄFER, Grahamstown, South Africa

Researching reasoning and autonomous learning in Mathematics when interacting with video clips

Introduction and background

This paper reports on ongoing empirical research in the VITALmathsLIC project – a collaboration between the FHNW in Switzerland and Rhodes University in South Africa (see www.ru.ac.za/vitalmaths). The VITALmathsLIC project produces, disseminates and researches silent and multilingual mathematics video clips that aim to expose mathematical ideas and concepts by using everyday material animations, as opposed to computer generated animations, in such a way that it makes these ideas accessible, inspiring, visual and motivating. The use of the growing databank of freely downloadable video clips is underpinned by different imperatives in the two countries. The South African imperative recognises the need for disseminating mathematical ideas to learners and teachers who do not have access to mathematical materials due to the geographical remoteness of their schools, poverty and general state neglect in providing appropriate learning materials and supporting both teachers and learners.

The continued production and use of the video clips are informed by a research agenda that critically reflects on the pedagogical implications of the individual video clips. Although the project does not necessarily prescribe a particular pedagogical approach, but promotes the autonomous use of the videos, it is interested in how the video clips are used in and out of the classroom. The VITALmathsLIC project has proved to be fertile ground for a host of Masters students in both Switzerland and South Africa to craft their individual research studies within the framework of this project. The first phase of the research agenda was driven by research questions that focused on the didactical implications of using the clips as teaching tools. The second phase, the focus of this paper, foregrounds research on the learning process when using the VITALmathsLIC video clips. The two aspects of learning that are at the heart of the two studies under consideration are autonomous learning and creative reasoning respectively. The rationale for this focus is that the VITALmathsLIC project explicitly promotes the use of video clips for the autonomous learning of the users. This includes the notion of creative reasoning.

This paper/presentation reports on the **research designs** and development of **research instruments** of two Masters studies that asked the following specific research questions:

In F. Caluori, H. Linneweber-Lammerskitten & C. Streit (Hrsg.), *Beiträge zum Mathematikunterricht 2015*. Münster: WTM-Verlag

Study 1
Do learners show creative mathematical reasoning abilities in interactions with peers (process)? Do learners show creative mathematical reasoning abilities as they justify their claim (product) (Kellen, 2014)?
Study 2
How do selected Grade 10 learners experience the autonomous use of selected VITALmaths video clips which incorporate manipulatives, in their learning of mathematics (Haywood, 2013)?

Theoretical considerations

The theoretical underpinnings for the two studies lie in the domain of mathematical reasoning and autonomous learning respectively. Von Glasersfeld (1995) sees reasoning as a fundamental process through which learners learn. One's ability to reason mathematically is largely determined by the use of skills such as imagination, concentration and generalization argues Campos (2010). Reasoning occurs in a social milieu and Krummheuer (2007) advocates that one cannot evaluate, and by implication research reasoning without taking the social context in which learners are learning into account. Lithner (2008) distinguishes between tow types of reasoning in mathematics learning, namely imitative learning and creative mathematical reasoning. It is the latter which is central to this paper. In the VITALmathsLIC project we advocate that the capacity to learn autonomously is integral to building capacity for creative reasoning provided that the appropriate milieu to interact with interesting and provoking stimulus materials exists. The notion that autonomy is a vital goal of education resonates strongly with this project. Learning autonomously is more nuanced that simply working independently – it is about the capacity and desire to think for oneself. Sfard's (2007) observation that autonomous learners explore the discourse of others to make the discourse-for-others into a discourse-for-oneself resonates strongly with our work.

Research design

The overwhelming challenge in both studies was to craft an authentic research environment and design that facilitated a genuine process of creative reasoning for Study 1 and autonomy for Study 2 in order to generate meaningful data to analyse and deliberate about. In brief, Study 1 was designed within the ambit of a youth development programme that supports marginalized and disadvantaged youths in the township of Grahamstown in South Africa. Selected groups of Grade 9 learners were asked to interact with selected VITALmathsLIC clips with minimal interference and prompts from the researcher. Their interactions were videotaped and the participants

were all interviewed. In Study 2, selected Grade 10 learners from a disadvantaged school in the Northern Cape of South Africa were issued with mobile phones on which selected video clips were downloaded. They were each asked to interact with these clips in their free time and return after two weeks to present and talk about their experiences. These presentations and interviews were video- and audio recorded respectively.

Research instruments and analysis

Reasoning is a complex construct and process to observe. What constitutes evidence for reasoning? One of the challenges for Study 1 was thus to develop and/or draw on an analytical instrument that contained a comprehensive set of observable criteria for creative reasoning. Study 1 drew from the work of Lithner (2008) who *inter alia* identified argumentation as a key component of reasoning. Two key aspects to argumentation are firstly the capacity to articulate a series of propositions that support a final conclusion and can be measured for its validity. This is the **product** aspect of argumentation. Secondly argumentation also involves the social interactions between people when different views are deliberated upon. This is the **process** aspect of argumentation. For the purpose of Study 1 the union or combination of product and process was thus taken as an indicator of creative reasoning. To analyse process, the study drew from Lithner (2008) and Krummheuer (2007). A rubric of criteria was adopted and adapted that described various types of participation and interactions. These included definitions of roles that participants could adopt such as author, relayer, ghostee and spokesman. A further rubric articulated criteria of reasoning such as comprehension of task, solution strategies, justification of solution strategies, justifications of solutions, making claims and articulation of how solutions created new tasks. To analyse product, the study drew on Lithner (2008) and Pierce (1992) in developing a further rubric of observable criteria that articulated product in terms of imagination/creativity, concentration, constructiveness and plausibility. Each item was further divided into observable units such as flexibility, fluency, novelty, sequentiality, continuity, mathematical anchordness, generalisability and conceptuality. One of the challenges for Study 2 was to develop an analytical framework that could bring forth and describe autonomous learning. On the return of the participants after interacting with the video clips that they were provided with on their mobile phones, they were each asked to do a presentation where they, *inter alia* described what they learnt about Pythagoras' theorem and fractions (the mathematical domains of the video clips), where, when and how they interacted with the clips and if they interacted with other people. They also complemented their presentations with models they

made using the type of materials that were evident in the video clips. After the presentations the participants were interviewed to source additional evidence of how they interacted autonomously with the video clips. The participants were also required to complete a pre- and post test to obtain a sense of learning in terms of the mathematical content that was acquired. A control group that did not participate in interrogating the videos was used to validate this aspect of the research. Current analysis of the data is both quantitative and qualitative. The former is used to analyse the pre- and post tests. Qualitative analysis strategies are used to analyse the recordings of the presentations and the interviews. Specifically, evidence is sought from the participants to see whether they adopted a discourse for themselves, as opposed to simlpy reproducing the discourse of the video clips.

Conclusion

Both studies are in the process of gathering and analyzing data, but early indicators are that creative reasoning and autonomy are indeed key components of learning.

References

Campos, D. (2010). Peirce's philosophy of mathematics education: fostering reasoning ability for mathematical inquiry. Studies in Philosophy and Education, 29, 421 – 439.

Haywood, T. (2013). An exploration of learners'autonomous learning of mathematics by using selected Visual Technology for Autonomous Learning of Mathematics (VITALmaths) video clips: A case study. Masters Research Proposal, Rhodes University, Education Department, Grahamstown.

Kellen, M. (2014). Observing and evaluating creative mathematical reasoning through selected VITALmaths video clips and collaborative argumentation. Masters Research Proposal, Rhodes University, Education Department, Grahamstown.

Krummheuer, G. (2007). Argumentation and participation in the primary classroom of teo episodes and related theoretical abductions. Journal of Mathematical Behaviour, 26, 60 – 82.

Lithner, J. (2008). A research framework for creative and imitative reasoning. Educational Studies in Mathematics, 67, 255 – 276.

Pierce, C. (1992). Reasoning and logic of things. In Ketner, K. (Ed.). Cambridge, MA: Harvard University Press.

Sfard, A. (2007). When the rules of discourse change, but nobody tells you: Making sense of mathematics learning from a commocognitive standpoint. Retrieved 28 July 2014 from http://lchc.ucsd.edu/mca/Mail/xmcamail.2009_04.dir/pdfLBjRfSfwm2.pdf.

von Glasersfeld, E. (1990). Radical constructivism: a way of knowing and learning. Studies in mathematical education series: 6. Bristol, PA: Falmer Press.